Title of the Invention

Printed- circuit board for High-Speed Communication

Background of the Invention

1. Field of the Invention

The present invention relates to a printed- circuit board for high-speed communication in which open pins of a multi-pin connector are terminated in order to eliminate influence of the open pins.

2. Description of the Related Art

In connecting many signal lines between printed circuit boards, a multi-pin connector is packaged in the printed circuit boards, and the signal lines are connected through the connector. This kind of device is disclosed in, for example, Japanese Patent Publication (unexamined) No. 2001-42981 (pages 3 to 5, Fig. 4). In a case where the number of the connector pins is larger than the number of the signal lines in the printed circuit boards, some of the connector pins are left as open pins where the signal lines are not connected. Hitherto, these open pins are left open or connected to the ground.

Fig. 13 is a graph showing a transmission characteristic of a signal line of a conventional printed- circuit board, and is a graph showing a transmission characteristic of a differential signal line connected to a connector pin.

Fig. 13 shows that transmission loss is small and signals are transmitted favorably in a low-frequency range. In a high-frequency range, the transmission loss increases at certain frequencies, and it is not possible to transmit signals in this frequency band. The transmission loss increases at frequencies higher than 3GHz, and spike transmission loss is generated in this frequency band.

Hitherto, the transmission characteristic at such a high frequency has not been examined, and the phenomenon of generation of spike transmission loss and a fact that the transmission loss is caused by the open pins connected to the ground have not been known. The mechanism of this transmission loss is explained below. Both ends of each open pin are connected to the ground, therefore the connector pin operates as a resonator when the connector pin has integral multiple the length of a half-wavelength of the signal. The connector pins are normally approximately 20mm in length, and the resonance frequency is approximately 3GHz in consideration of a relative dielectric constant of a material such as plastic supporting the connector pins. The open pins are joined to the signal pins connected to the signal lines, therefore energy of the signals flowing through the signal pins is absorbed by the open pins at the resonance frequency, and the transmission loss of the signal lines increases. Even if the open pins are left open, the transmission loss is increased by the same mechanism when the connector pins resonate.

Japanese Patent Publication (unexamined) No. 2001-42981 discloses an example where a connector composing a final stage of a signal line is provided with a termination board where a terminating resistance is packaged in order to reduce noises reflected from the final stage of the signal line. However, this construction has a problem that it is not possible to eliminate the influence of the open pins and prevent generation of spike transmission loss in the high-frequency band higher than 3GHz.

Summary of the Invention

The present invention was made to solve the above-discussed problems and has an object of obtaining a printed- circuit board for high-speed communication in which the influence of the open pins

of the multi-pin connector is eliminated.

A printed- circuit board for high-speed communication according to the invention includes a first printed-circuit board having a first signal line for transmitting high-frequency signals, a second printed-circuit board having a second signal line that is connected to the first signal line of the foregoing first printed-circuit board and transmits high-frequency signals, and a connector provided with many pins and arranged between the first printed-circuit board and the second printed-circuit board so that the first signal line and the second signal line are connected by the pins, and elements for giving loss are connected to open pins where the first signal line and the second signal line of the connector are not connected.

According to the invention constructed as described above, it is possible to reduce generation of transmission loss of the signal lines.

Brief Description of the Drawings

Fig. 1 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 1 of the invention.

Fig. 2 is a graph showing a transmission characteristic of a signal line of the printed- circuit board for high-speed communication according to Embodiment 1 of the invention.

Fig. 3 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 2 of the invention.

Fig. 4 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 3 of the invention.

Fig. 5 is a diagram showing a printed- circuit board for

high-speed communication according to Embodiment 4 of the invention.

Fig. 6 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 5 of the invention.

Fig. 7 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 6 of the invention.

Fig. 8 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 7 of the invention.

Fig. 9 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 8 of the invention.

Fig. 10 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 9 of the invention.

Fig. 11 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 10 of the invention.

Fig. 12 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 11 of the invention.

Fig. 13 is a graph showing a transmission characteristic of a signal line of a conventional printed- circuit board.

Description of the Preferred Embodiments

Embodiment 1.

Fig. 1 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 1 of the invention. Signal pins where signal lines are connected are not show in Fig. 1.

In Fig. 1, a signal line (a first signal line) of a backboard 1 (a first printed-circuit board) and a signal line (a second signal line) of a daughter board 2 (a second printed-circuit board) are connected by a connector 3. The connector 3 has connector pins 4 to 9 that are open. Terminating resistances 10 are arranged on both sides of each of these connector pins 4 to 9, and the other side

of each terminating resistance is connected to the ground of the printed-circuit board. It is also preferable that the other side of each terminating resistance is connected to a power supply.

Fig. 2 is a graph showing a transmission characteristic of the signal line of the printed- circuit board for high-speed communication according to Embodiment 1 of the invention.

Fig. 2 shows transmission loss to the frequency, and spike transmission loss is not generated in the transmission characteristic of the signal lines.

As shown in Fig. 1, Embodiment 1 is aimed to reduce a resonance characteristic of the open pins and reduce generation of spike transmission loss in the signal lines by arranging the terminating resistances 10 at both ends of each open pin. It is not necessary that the value of the terminating resistances 10 coincides with characteristic impedance of the signal lines provided that appropriate loss is given to the open pins and the resonance characteristic of the open pins is lowered when the terminating resistances 10 are at the value.

According to Embodiment 1, generation of transmission loss of the signal lines is reduced by arranging the terminating resistances at both ends of each open pin.

Embodiment 2.

Fig. 3 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 2 of the invention.

In Fig. 3, reference numerals 1 to 10 are the same with those in Fig. 1. In Fig. 3, the open pins are connected to each other on the backboard 1 side, the terminating resistances 10 are arranged

on the daughter board 2 side, and the other side of each terminating resistance 10 is connected to the ground of the printed-circuit board. It is also preferable that the other side of each terminating resistance is connected to the power supply.

According to the construction as described above, spike transmission loss is not generated in the transmission characteristic of the signal lines. Moreover, according to this construction, it is not necessary to arrange the terminating resistances 10 on the backboard 1, and this has the effect of reducing the number of parts packaged in the backboard 1 and facilitating assembling of the backboard 1. The combinations of the open pins connected to each other on the backboard 1 can be arranged in any way.

Embodiment 2 has the effect of preventing generation of spike transmission loss in the transmission characteristic of the signal lines.

Moreover, it is not necessary to arrange the terminating resistances on the backboard side, and this has the effect of reducing the number of parts packaged in the backboard and facilitating assembling the parts in the printed-circuit board.

Embodiment 3.

Fig. 4 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 3 of the invention.

In Fig. 4, reference numerals 1 to 10 are the same with those in Fig. 1. In Fig. 4, the open pins of the connector 3 are connected in a daisy chain connection, and only two terminating resistances 10 are arranged at both ends of the daisy chain connection on the daughter board 2 side in this construction. While the other side

of each terminating resistance 10 is connected to the ground in Fig. 4, it is also preferable that the other side of each terminating resistance is connected to the power supply. According to the construction as described above, it is possible to sharply reduce the number of the terminating resistances 10 and prevent generation of spike transmission loss.

Embodiment 3 has the effect of sharply reducing the number of the terminating resistances and preventing generation of spike transmission loss.

Embodiment 4.

Fig. 5 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 4 of the invention.

In Fig. 5, reference numerals 1 to 10 are the same with those in Fig. 1. In Fig. 5, the open pins are connected to each other on the daughter board 2 side, the terminating resistances 10 are arranged on the backboard 1 side, and the other side of each terminating resistance 10 is connected to the ground of the printed-circuit board. It is also preferable that the other side of each terminating resistance is connected to the power supply.

According to the construction as described above, spike transmission loss is not generated in the transmission characteristic of the signal lines. Moreover, according to this construction, it is not necessary to arrange the terminating resistances 10 on the daughter board 2, and this has the effect of reducing the number of parts packaged in the daughter board 2 and facilitating assembling of the daughter board 2. The combinations of the open pins connected to each other on the daughter board 2 can be arranged in any way.

According to Embodiment 4, the open pins are connected to each other on the daughter board side, and the terminating resistances are arranged on the backboard side, and as a result, it is possible to reduce the number of the terminating resistances and also reduce generation of transmission loss of the signal lines.

Embodiment 5.

Fig. 6 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 5 of the invention.

In Fig. 6, reference numerals 1 to 10 are the same with those in Fig. 1. In Fig. 6, the open pins of the connector 3 are connected in a daisy chain connection, and only two terminating resistances 10 are arranged at both ends of the daisy chain connection on the backboard 1 side in this construction. While the other side of each terminating resistance 10 is connected to the ground in Fig. 6, it is also preferable that the other side of each terminating resistance 10 is connected to the power supply. According to the construction as described above, it is possible to sharply reduce the number of the terminating resistances 10 and prevent generation of spike transmission loss.

According to Embodiment 5, the open pins are connected in a daisy chain connection, and two terminating resistances are arranged on the backboard 2 side, and as a result, it is possible to sharply reduce the number of the terminating resistances and also reduce generation of transmission loss of the signal lines.

Embodiment 6.

Fig. 7 is a diagram showing a printed- circuit board for

high-speed communication according to Embodiment 6 of the invention.

In Fig. 7, reference numerals 1 to 10 are the same with those in Fig. 1. In Fig. 7, the open pins of the connector 3 are connected in parallel, and terminating resistances are arranged on both sides of the parallel connection in this construction. While the other side of each terminating resistance 10 is connected to the ground in Fig. 7, it is also preferable that the other side of each terminating resistance 10 is connected to the power supply. According to the construction as described above, it is possible to sharply reduce the number of the terminating resistances 10 and prevent generation of spike transmission loss.

According to Embodiment 6, the open pins are connected in parallel, and two terminating resistances are arranged on the backboard side and the daughter board side, and as a result, it is possible to sharply reduce the number of the terminating resistances and also reduce generation of transmission loss of the signal transmission lines.

Embodiment 7.

Fig. 8 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 7 of the invention.

In Fig. 8, reference numerals 1 to 10 are the same with those in Fig. 1. In Fig. 8, the open pins of the connector 3 are connected in parallel, one side of the parallel connection is folded back to the daughter board side, and the terminating resistances are arranged only on the daughter board side in this construction. While the other side of each terminating resistance 10 is connected to the ground in Fig. 8, it is also preferable that the other side of each terminating resistance 10 is connected to the power supply. According to the

construction as described above, it is possible to sharply reduce the number of the terminating resistances 10 and prevent generation of spike transmission loss.

According to Embodiment 7, the open pins are connected in parallel, and two terminating resistances are arranged on the daughter board side, and as a result, it is possible to sharply reduce the number of the terminating resistances and also reduce generation of transmission loss of the signal transmission lines.

Embodiment 8.

Fig. 9 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 8 of the invention.

In Fig. 9, reference numerals 1 to 10 are the same with those in Fig. 1. In Fig. 9, the open pins of the connector 3 are connected in parallel, one side of the parallel connection is folded back to the backboard side, and the terminating resistances are arranged only on the backboard side. While the other side of each terminating resistance 10 is connected to the ground in Fig. 9, it is also preferable that the other side of each terminating resistance 10 is connected to the power supply. According to the construction as described above, it is possible to sharply reduce the number of the terminating resistances 10 and also prevent generation of spike transmission loss.

According to Embodiment 8, the open pins are connected in parallel, and two terminating resistances are arranged on the backboard side, and as a result, it is possible to sharply reduce the number of the terminating resistances and also reduce generation of transmission loss of the signal transmission lines.

Embodiment 9.

Fig. 10 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 9 of the invention.

In Fig. 10, reference numerals 1 to 10 are the same with those in Fig. 1. In Fig. 10, the open pins are connected to each other on the backboard 1 side and on the daughter board 2 side, and the terminating resistances are arranged on the lines each connecting one open pin with another. While Fig. 10 shows an example where the terminating resistances are arranged on the lines on the daughter board side, it is also preferable that the terminating resistances are arranged on the backboard side or on both of the daughter board side and the backboard side. According to the construction as described above, it is possible to prevent generation of spike transmission loss without connecting the open pins to the power supply or the ground.

According to Embodiment 9, the open pins are connected to each other, and the terminating resistances are arranged on the lines connecting the open pins, and as a result, it is possible to reduce generation of transmission loss of the signal transmission lines without connecting the open pins to the power supply or the ground.

Embodiment 10.

While the backboard 1 (the first printed-circuit board) and the daughter board 2 (the second printed-circuit board) are used in the examples shown in Embodiments 1 to 9, it is also preferable to apply the invention to a device in which plural daughter boards (plural printed-circuit boards) are connected through connectors.

Fig. 11 shows an example where three daughter boards are used

in a printed- circuit board for high-speed communication.

In Fig. 11, numerals 2, 11, and 15 are daughter boards, numerals 3, 14, and 18 are connectors, numerals 4, 12, and 16 are connector open pins, and numerals 10, 13, and 17 are terminating resistances.

The terminating resistances 10 are arranged at both ends of the open pin 4 of the connector 3, and the other side of each terminating resistance is connected to the ground of the printed-circuit board or the power supply. In the same way, the terminating resistances 13 are arranged at both ends of the open pin 12 of the connector 14, and the other side of each terminating resistance is connected to the ground of the printed-circuit board or the power supply. The terminating resistances 17 are arranged at both ends of the open pin 16 of the connector 18, and the other side of each terminating resistance is connected to the ground of the printed-circuit board or the power supply. According to the construction as described above, it is possible to prevent generation of spike transmission loss in the transmission characteristic of the signal lines in all the daughter boards.

While Fig. 11 shows an example where the open pins are terminated individually, it is also preferable that plural open pins are connected in a daisy chain connection or connected in parallel.

According to Embodiment 10, the terminating resistances are arranged on the open pins of the plural connectors connected to the backboard, and as a result, it is possible to prevent generation of spike transmission loss in the transmission characteristic of all the signal lines.

Embodiment 11.

While Embodiment 10 shows an example where the open pins of

the connectors of the plural daughter boards are individually provided with the terminating resistances, it is also preferable to collectively terminate the open pins of the plural connectors.

Fig. 12 is a diagram showing a printed- circuit board for high-speed communication according to Embodiment 11 of the invention.

In Fig. 12, reference numerals 1 to 18 are the same with those in Fig. 11. Numeral 20 is a line in the backboard. The open pin 4 of the connector 3 is provided with the terminating resistance 10, and the other side of the terminating resistance 10 is connected to the ground or the power supply. The other side of the open pin of the connector 3 is connected to the open pin 12 of the connector 14 arranged on the daughter board 11 through the line 20 in the backboard. The other side of the open pin 12 is connected to the ground or the power supply through the terminating resistance 13. According to the construction as described above, it is possible to sharply reduce the number of the terminating resistances and prevent generation of spike transmission loss.

While Fig. 12 shows an example where the open pins are terminated individually, it is also preferable that plural open pins are connected in a daisy chain connection or connected in parallel.

According to Embodiment 11, the open pins of the two connectors are connected, and the terminating resistances are arranged at both ends of the open pins, and as a result, it is possible to reduce generation of spike transmission loss of the signal transmission lines.

Embodiment 12.

While the other side of each terminating resistance is connected to the ground or the power supply in Embodiments 1 to 11, the same

advantages are obtained in a case where the other side of each terminating resistance is open. According to the construction described above, it is possible to prevent generation of spike transmission loss.

According to Embodiment 12, it is possible to prevent generation of spike transmission loss without arranging a wiring pattern on the other side of the terminating resistance.

Embodiment 13.

The terminating resistance is connected to the open pin of the connector in the examples described in Embodiments 1 to 12. The terminating resistance is composed of a normal resistance part, a resistance built in a board, a printed resistance, a high-resistance line, a relatively long line, or the like. The same advantages are obtained by arranging a condenser element or an inductance element. In other words, the open pin of the connector is not directly connected to the ground or the power supply but is connected to an element for giving some loss, and this makes it possible to prevent generation of spike transmission loss.

The element for giving loss is, for example, directly connected to the open pin of the connector or connected through a line, a via, or a through hole.

According to Embodiment 13, generation of spike transmission loss is prevented in a relatively wide frequency range.

Embodiment 14.

While the terminating resistances are connected to all the open pins of the connector in the examples described in Embodiments

1 to 13, the same advantages are obtained by arranging the terminating resistances on a part of the open pins of the connector. The open pins near the signal lines exert a bad influence upon the transmission characteristic of the signal lines, therefore it is possible to prevent generation of spike transmission loss by arranging the terminating resistances on the open pins near the signal lines.

According to Embodiment 14, it is possible to prevent generation of spike transmission loss by arranging terminating resistances on not all the open pins.

Embodiment 15.

While methods for terminating the open pins are disclosed in Embodiment 1 to 14, it is also preferable to mix these methods for terminating the open pins.